Original Article
ISSN (Online): 2582-7472

ShodhKosh: Journal of Visual and Performing Arts
January-June 2024 5(1), 1653–1660

MECHANICAL PROPERTIES OF BANANA FIBRE REINFORCED POLYSTER COMPOSITES

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ABSTRACT

n the present scenario, there has been a rapid attention in research and development in the natural fibre composite field due to its better formability, abundant, renewable, cost-effective and eco-friendly features. This work makes use of easily available banana fibres as a reinforcement material for the polyester matrix to produce the effective composite material. The Banana fibre reinforced polyester composite material is prepared by adopting Hand Lay-up method subjected to a Tensile and Impact tests and the results are analysed. The tensile strength of the single layer banana fibre composite is greater than the double layer banana fibre composite, it is because of the improper load distribution in the double layer banana fibre composite material. Since the tensile strength depends on the interfacial bonding between the matrix and fibres, the interfacial bonding in the double layered composite is lesser when compared to that of the single layered composite material. The impact strength of single layer banana fibre composite is lesser than the double layer banana fibre composite because as the fibre content increases the energy absorbing capacity of the material also increases. The impact strength of the banana fibres is found to be comparable and better than that of the glass fibres, so banana fibres can replace glass fibres in terms of its impact strength.

Keywords: Banana Fibre, Hand Lay-Up Method, Polyester Matrix, Tensile Strength, Impact Strength

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DOI
10.29121/shodhkosh.v5.i1.2024.4505

Funding: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

1. INTRODUCTION

Since two decades natural fibre composites are emerging as realistic alternatives to replace the glass reinforced composites in many applications. Natural fibres such as banana, coir, sisal and jute have attracted the attention of scientists and technologists for application in consumer goods, low cost housing and other civil structures. Natural fibres have many advantages compared to synthetic fibres like low density, cheaper, acceptable specific properties and also they are renewable and biodegradable. These composites possess high strength and stiffness, good thermal and acoustic insulating properties and high resistance to fracture. However, the main disadvantage of these natural fibre polymer composites seems to be the compatibility between the hydrophilic natural fibres and the hydrophobic matrix that makes necessary to use coupling agents in order to improve the adhesion between fibre and matrix1-3.

The bonding interfacial adhesion between the natural fibre and the polymer matrix is affected by mechanical interlocking, attractive forces and chemical bonds between the natural fibre and the resin. Natural fibbers have hydroxyl groups and hydrogen bonds can therefore be formed to the surface of the natural fibre. The bond strength in natural fibre reinforced composite is decreased by the absorption of moisture4, 5. The hydrophilic fibres absorb the moisture from the environment and hydrogen bonds are formed between hydroxyl group of the cellulose molecule and the absorbed water. Moisture absorption also affects the dimensional stability of natural fibre. This results to poor adhesion between resin and matrix which causes debonding. Drying fibre before processing is very important because it increase the mechanical properties of the composites6-9.

Natural fibres have many important advantages over the use of synthetic fibres. Currently, many types of natural fibres have been investigated as reinforcement in polymer matrix including flax, hemp, jute straw, wood, rice husk, wheat, barley, oats, rye, cane (sugar and bamboo), grass, reeds, kenaf, ramie, oil palm empty fruit bunch, sisal, coir, hyacinth, pennywort, kapok, paper mulberry, raphia, banana fibre, pineapple leaf fibre and papyrus. The chemical composition of fibre is cellulose, hemicelluloses, lignin, pectin and waxy substances. The natural fibres are hydrophilic in nature and thus are treated with suitable chemicals to decrease the hydroxyl group in the fibres. Chemical treatment reacts with hydroxyl group of the natural fibre and improves hydrophobic characteristic and improves interfacial adhesion with polymer matrix10.

1.1. BANANA FIBRES

Banana fibre which is obtained from the plant Musa Saptentum linn has high cellulose content and low microfibrillar angle, makes this fibre a good candidate to be used as reinforcement in polyester matrix11-13. Banana fibre is a natural fibre as shown in Figure.1 it has its own physical and chemical characteristics and many other properties that make it a fine quality fibre and chemical compositions of banana fibre are given in Table.1.

- Appearance of banana fibre is similar to that of bamboo fibre and ramie fibre, but its fineness and spin ability is better than the two.
- The chemical composition of banana fibre is cellulose, hemicellulose, and lignin.
- It is highly strong fibre.
- It has smaller elongation.
- It has somewhat shiny appearance depending upon the extraction & spinning process.
- It is light weight.
- It has strong moisture absorption quality. It absorbs as well as releases moisture very fast.
- It is bio- degradable and has no negative effect on environment and thus can be categorized as eco-friendly fibre.
- Its average fineness is 2400Nm.
- It can be spun through almost all the methods of spinning including ring spinning, open-end spinning, bast fibre spinning, and semi-worsted spinning among others.

Figure. 1 Banana fibres

Table 1: Chemical composition of Banana fibre

fibre	Cellulose %	Hemi cellulose %	Lignin %	Pectin %
Banana	60-65	6-9	5-10	3-5

The objective of this study is to focus on makes use of easily available banana fibres as a reinforcement material for the polyester matrix to produce the effective composite material. Chemical modification of natural fibres is necessary for increased adhesion between the hydrophilic fibres and hydrophobic matrix. The obtained composite material is checked for its Tensile and Impact strength. To study the mechanical properties of single layer and double layer reinforced polyester composite material and compare the mechanical properties of Banana fibre composite material with the other fibre reinforced composite material.

2. METHODOLOGY

2.1. MATRIX PREPARATION

The unsaturated General purpose polyester resin of grade GSTAR1101 purchased from Aryan composites Pvt Ltd, Bengaluru, India. The resin has 1900 kg/m3density. Cobalt naphthanate as hardener and methyl ethyl ketone peroxide (MEKP) as catalyst are used. The polyester resin and hardener is mixed in a proper proportion of 4:1 and catalyst is added to it at 1.5% of resin14.

2.2. BANANA FIBRE PROCESSING AND WEAVING

The extraction of the natural fibre from the plant required certain care to avoid damage. In the present experiments, initially the banana plant sections were cut from the main stem of the plant and then rolled lightly to remove the excess moisture. Impurities in the rolled fibres such as pigments, broken fibres, coating of cellulose etc. were removed manually by means of comb, and then the fibres were cleaned and dried. This mechanical and manual extraction of banana fibres was tedious, time consuming, and caused damage to the fibre. Consequently, this type of technique cannot be recommended for industrial application. A special machine was designed and developed for the extraction of banana fibres in a mechanically automated manner. It consisted mainly of two horizontal beams whereby a carriage with an attached and specially designed comb, could move back and forth. The fibre extraction using this technique could be performed simply by placing a cleaned part of the banana stem on the fixed platform of the machine, and clamped at the ends by jaws. This eliminated relative movement of the stem and avoided premature breakage of the fibres. This was followed by cleaning and drying of the fibres in a chamber at 20oC for three hours. These fibres were then labelled and ready for lamination process. After extraction of fibre, weaving is done in the looms as per normal process like any other material15.

2.3. PROCEDURE (HAND LAY-UP METHOD)

- The mould used for woven composite fibres is made from rectangular plywood 200 mm in length and 200 mm in width. For the other side of the mould is also made in a rectangular form using plywood of 200 mm in length, and 200 mm in width and it has to be coated with plastic as shown in Figure.2 . The functions of this upper side of plywood are to cover the fibre after the polyester is supplied and also to avoid the debris entering into the composite parts during the curing time16.

Figure 2 Mould made from rectangular plywood

- Before the matrix is laid up on the mould, the mould should be well cleaned and dry. For this reason, a release agent is laid up on the mould.
- Using a special brush, the matrix mixture is laid up uniformly for the first layer on to the mould.
- The first woven banana fibre was added into the mould.
- Another layer of matrix was applied uniformly on the first layer of the woven banana fibre.
- The whole set up is then compressed under 10 Kg load.

- Then the specimen is cured up to -70 to 150oC.
- Specimen 2 is prepared by following the same procedure as that of specimen 1.
- But the second layer of woven banana fibre and matrix is then added. The Banana fibre Composite of single Layer and double layer as shown in Figure 3.

(a) (b)

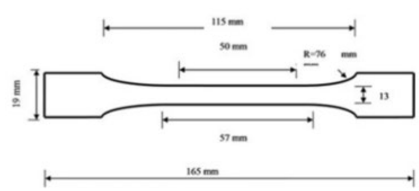
Figure 3 Banana fibre Composite, (a) Single Layer and (b) Double layer

2.4. TENSILE TESTING

The banana fibre composite material obtained from the hand layup method is the cut into an ASTM D638-10 standard with dimensions of 165 mm x13 mm x 4 mm. Then the specimen is given to check its tensile strength. The tensile strength of the composite has measured with a universal testing machine of model TUE-400(C), the Figure 4 shows tensile test specimen for banana fibre reinforced polyester composite.

(a)

(b)



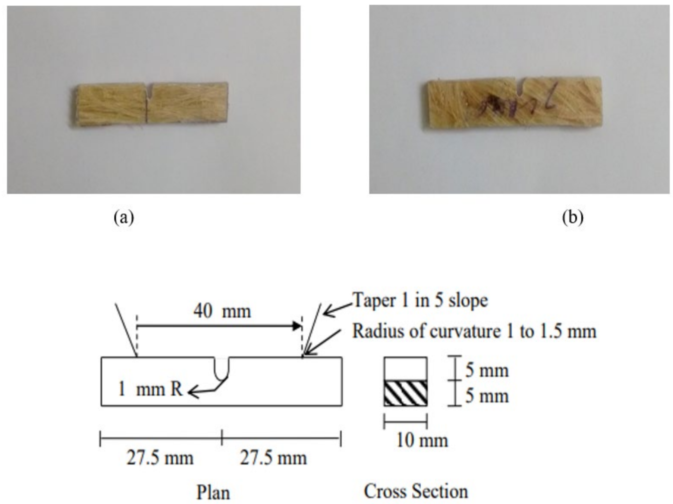
(c)

Figure 4 Banana fibre reinforced polyester composite tensile test specimen

Single Layer, b) Double Layer and c) Standard tensile test specimen (ASTM D638-10)

2.5. IMPACT TESTING

The banana fibre composite specimen that fits into the Charpy impact test specimen is rectangular with a notch cut in one side. The notch allows for a predetermined crack initiation location. The specimen is cut into an ASTM standard of 55mm x 10mm x 4mm as shown in Figure 4. Pendulum type Impact testing machine is used for the test. The machine consists of a pendulum of mass 18.748 kg, length = 825 mm with an angle of swing of 140o



(a) (b) (c)

Figure 5 Impact test specimen (a) single layer, (b) Double layer specimen and c) Standard Impact test specimen

3. RESULTS AND DISCUSSIONS

The specimens obtained are tested for tensile strength and the impact strength using UTM machine and charpy impact testing machine respectively. The test is conducted for three trials for both specimens and the average is calculated from them.

3.1. TENSILE TEST

The banana fibre composite material obtained from the hand layup method is cut into an ASTM D638-10 standard with dimensions of 165 mm x13 mm x 4 mm. Then the specimen is given to check its tensile strength. The tensile strength of the composite is measured with a universal testing machine of model TUE-400(C). The maximum loads of 1.76 kN and 1.16 kN are applied to the 1 layer and 2 layer specimens respectively are tabulated as shown in Figures 6. and the average values of three specimens are shown in Table 2.

Table 2 Observations of tensile strength

Material	Tensile strength in MPa			
	1	2	3	Average
No fibre	30	30	30	30
Single layer of fibre	33.52	32.68	33.76	33.32
Double layer of fibre	16.98	19.69	17.56	18.07

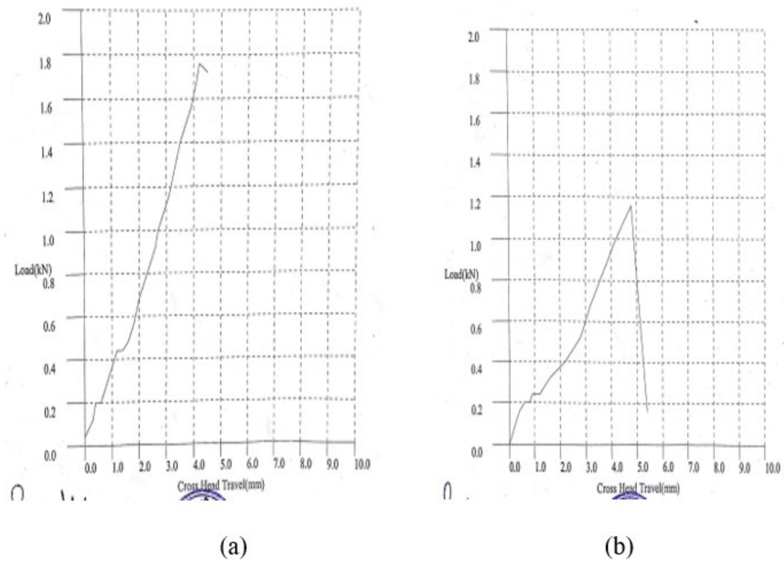


Figure 6 Load v/s Cross head travel for (a) 1 layer and (b) 2 layer specimen

The results obtained from the testing shows that as the volume fraction of the fibres increases, the tensile strength decreases which is shown the Table 2. This is because of the unequal distribution of the load to the fibres. Tensile strength always depends on the interfacial bonding between the matrix reinforcement and the inherent properties of the composite ingredients. The interfacial bonding of double layered banana fibre composite is less than that of the single layered banana fibre composite.

3.2. IMPACT TEST

The energy absorption or toughness of homogeneous isotropic materials has measured by Charpy impact tests. The readings obtained from the impact test were tabulated as shown in Table 3.

Table 4.2 Observation of energy absorbed by Impact test

Material	Energy absorbed in Joules			
	1	2	3	Average
No fibre	5.82	5.82	5.82	5.82
Single layer of fibre	5.9	6.1	6	6
Double layer of fibre	7.8	8.2	8	8

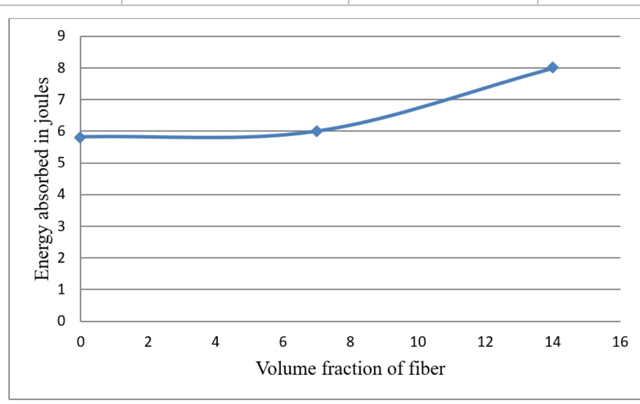


Figure 7 Energy absorbed in joules v/s volume fraction

The Average readings shown in the above table 3 are plotted in the graph of Energy absorbed by the specimen v/s volume fraction of fibres. The obtained graph is shown in Figure 7. Impact strength v/s Energy absorbed by the fibres indicates that the increase in volume fraction increases the energy absorbed by the specimens. It is because as the fibre content increases the energy absorbing capacity of the material also increases.

The impact strength of single layer banana fibre composite (i.e., 6Joules) is lesser than the double layer banana fibre composite (i.e., 8Joules). It is because as the fibre content increases the energy absorbing capacity of the material also increases. The impact strength of the banana fibres is found to be comparable and better than that of the glass fibres, so banana fibres can replace glass fibres in terms of its impact strength.

4. CONCLUSIONS

This work presents make use of easily available banana fibres as a reinforcement material for the polyester matrix to produce the effective composite material. The Banana fibre reinforced polyester composite material is prepared by adopting Hand Lay-up method subjected to a Tensile and Impact tests and the results are analysed, the main results are listed below.

- The tensile strength of the single layer banana fibre composite (i.e., 33.32MPa) is greater than the double layer banana fibre composite (i.e., 18.07MPa). It is because of the improper load distribution in the double layer banana fibre composite material. Since the tensile strength depends on the interfacial bonding between the matrix and fibres, the interfacial bonding in the double layered composite is lesser when compared to that of the single layered composite material.
- Tensile properties of banana fibres are much lower than those of glass fibres but their specific properties, especially stiffness, is comparable to the glass fibres.
- The impact strength of single layer banana fibre composite (i.e., 6Joules) is lesser than the double layer banana fibre composite (i.e., 8Joules). It is because as the fibre content increases the energy absorbing capacity of the material also increases.
- The impact strength of the banana fibres is found to be comparable and better than that of the glass fibres, so banana fibres can replace glass fibres in terms of its impact strength.
- It can be concluded that the banana fibres which is of low cost and less weight can be used many automotive, aerospace, constructional and household applications.

CONFLICT OF INTERESTS

None.

ACKNOWLEDGMENTS

None.

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